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Nuclear Energy University Programs (NEUP)
Fuel Cycle Technologies Program Overview

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NEUP FY 2012 Annual Planning Workshop

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Where We Are Today?

Global demand for energy and concerns about climate change has accelerated deployment of reactor and fuel cycle facilities worldwide

There is a continuing build up of nuclear waste from commercial nuclear plants and stockpile of DOE wastes stored across the country. (Fukushima)

Recognition that there is a need for a waste management strategy
- **Interim Storage**
- **Fuel Cycle Alternatives**
- **Disposal Options**

A Blue Ribbon Commission conducting a comprehensive evaluation of policies for managing the back end of the nuclear fuel cycle, including advanced fuel cycle technologies

The Fuel Cycle Technology Program seeks to develop innovative technologies that represent significant advantages in terms of economics, proliferation resistance, resource utilization and waste management

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Fuel Cycle R&D Is Science-Based, Engineering-Driven

By the middle of the next decade, engineering scale experiments on a new generation of advanced technologies will enable their deployment by the middle of the century

- **Defining and considering a broad range of fuel cycle technologies against a set of criteria:**
  - **Nuclear waste management**
  - **Resources**
  - **Proliferation risk**
  - **Safety**
  - **Security**
  - **Economics**
  - **Environmental impacts.**

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Where Are We Today? Working Toward an Integrated Approach

Front End

Uranium Resources

- Conventional production
- Innovative approaches
  - U Seawater

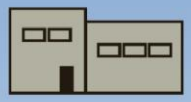
Fuel Fabrication

- Safety enhanced LWR fuel
- Higher performance
  - Improved burnup
  - Accident tolerance

Reactors

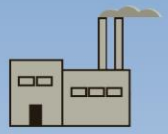
Back End

Interim Storage



- Evaluating extended time frames
- Transport after storage

Recycle



- Separations
- Recycled fuel
- Secondary waste treatment

Disposal

- Alternative geologies
- Alternative waste forms

Optimize through systems analysis and engineering

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How Are We Organized?

NE-5
Deputy Assistant Secretary for Fuel Cycle Technologies

Robert Price NE-51 Systems Engineering and Integration	Andrew Griffith NE-52 Fuel Cycle Research and Development	Bill Boyle NE-53 Used Nuclear Fuel Disposition Research and Development	Bill Szymanski NE-54 Uranium Management and Policy
• Fuel Cycle Options Analysis (FC-5)	• Sep/ Waste Forms (FC-1) • Advanced Fuels (FC-2) • Nuclear Materials • Safeguarding and Instrumentation (FC-3)	• Used Fuel Storage and Transportation (FC-4.1) • Used Fuel Disposal (FC-4.2)	

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Used Nuclear Fuel Disposition: A Strategy Tied to the Future of Nuclear Energy

Recommendations made by the BRC will guide the Fuel Cycle R&D strategy

- **Blue Ribbon Commission will provide a policy and planning framework that will help guide management of used nuclear fuel and fuel cycle research and development**
- **BRC draft report affirms the need for fuel cycle and separations research**
- **The final report anticipated by the end of Jan. 2012 will be informed by input from a broad range of stakeholders**

U.S. government conducting R&D aimed at addressing challenges to expanded use of nuclear energy, including advanced fuel cycle technologies, while addressing waste management and supporting non-proliferation objectives

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Key Recommendations of the Draft BRC Report (July 29, 2011)

1. An approach to siting and developing waste management and disposal facilities that is adaptive, staged, consent based, transparent, and standards and science based
2. New single-purposed organization to develop/implement an integrated program
3. Assured access by the nuclear waste program to the balance of the NWF and revenues generated by annual payments
4. Prompt efforts to develop one or more permanent deep geological facilities for safe disposal of SNF and HLW
5. Prompt efforts to develop one or more consolidated interim storage facilities as part of an integrated plan for the back end

6. Stable, long term support for RD&D on advanced reactor and fuel cycle technologies that have the potential to offer substantial benefits
7. International leadership to address global non-proliferation concerns and improve safety and security of nuclear facilities and materials worldwide

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Fuel Cycle Technology Program Seeks University Research Proposals

Fuel Cycle Technology Program seeks university proposals that advance:

1. **Near term improvements to LWR safety as part of the once through fuel cycle and in technologies available for storage and disposing of SNF and HLW**
2. **Longer term efforts to advance potential "game changing" technologies that can achieve large benefits over today's fuel cycle technologies**

Consider potential teaming arrangements that enable universities to utilize their unique capabilities and facilities as well as those potentially accessible at laboratories and industry

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Separations and Waste Form Development (FC-1)

Goals: Developing the next generation of fuel cycle and waste management technologies that enable a sustainable fuel cycle, with minimal processing, waste generation and potential for materials diversion

Key technology challenges:

- **Economic recovery of transuranic elements for recycle/transmutation**
- **Minimizing low and high level waste**

- **Separations workshop was held July 27-28, 2011, in Washington DC on common areas of separations research across DOE programs (NE, NNSA, EM)**
- **Report anticipated by the end of August 2011 may identify new areas for R&D collaboration**

Workshop website:
http://events.energetics.com/NuclearSeparationsTechnologyWorkshop/index.html

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Separations and Waste Form (FC-1) Focus Areas for University Proposals

- **Key university research needs for separations includes:**
  - ***Chemistry and Speciation of the Actinides and Key Fission Products (Cs, Tc, I)***
  - ***Design of Molecules and Materials with Selective Separation Properties***
  - ***Scale-up of Separation Processes from Bench-Top to Plant***
  - ***Interface issues between Separations and Waste Forms/Fuel Fabrication***

- **Key university research needs for waste forms includes:**
  - ***Alternative waste forms that have the potential of significantly increased waste loading and durability***
  - ***Tailored waste forms that have higher reliance on engineering versus natural barriers***

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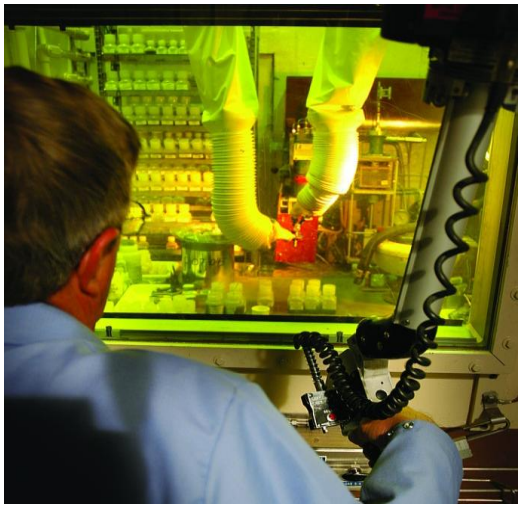
Advanced Fuel Development (FC-2)

Goals:

- Develop "next generation LWR fuels and cladding" whose characteristics include improved operating margin, accident tolerant and high burnup fuels
- Develop transmutation metal fuels with a high degree of tolerance to accident conditions and that represent advancements in resource utilization and reduced waste



- Focus of the research
  - Innovative LWR Fuels and Cladding
  - Metal Fast Reactor Fuels
  - Advanced fuel fabrication methods with a low degree of losses

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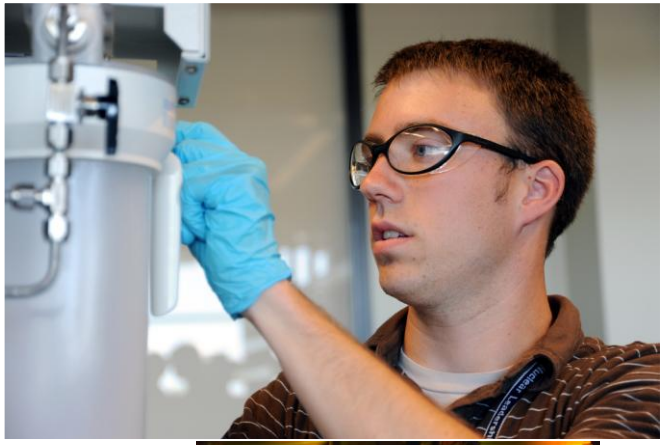
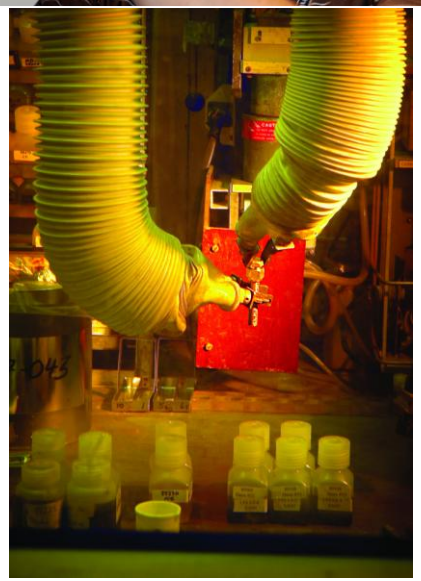
Advanced Fuels (FC-2) Focus Areas for University Proposals

- **Key university research needs for advanced fuels includes:**
  - ***Advanced fabrication technologies; research aimed at reducing fabrication losses while increasing fuel quality and consistency***
  - ***Fabrication process models (e.g., compaction, sintering, and other fuel materials studies)***
  - ***Develop "real-time" in-pile instrumentation, to advance understanding of fuel behavior and predict performance at the micro-structural level***
  - ***Developing predictive, physics-based fuel performance models at the microstructural level based on separate effects tests***
  - ***Develop innovative out of pile testing capabilities to advance understanding of fuel at the beginning of life stage and micro-structural level***





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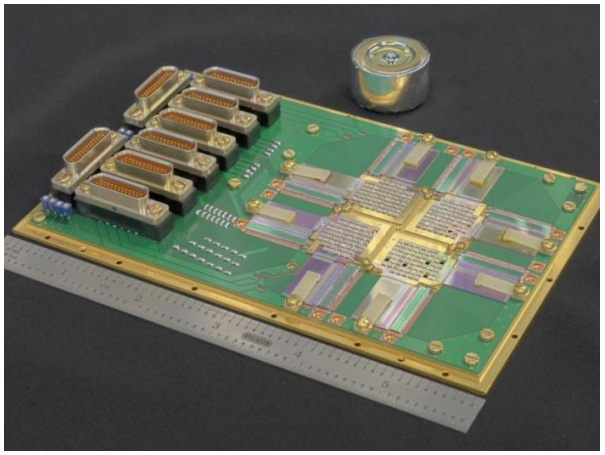
Nuclear Materials Safeguarding and Instrumentation FC-3

Goals:

- **Development of instrument capable of real-time measurement of group transuranics in advanced fuel cycle systems**
- **Develop proliferation risk analyses applied to advanced fuel cycles and spent fuel storage**



- **Focus of the research**
  - **Developing nuclear material management systems for advanced nuclear systems**
  - **Improving nuclear material management systems at large fuel cycle facilities**
  - **Moving from reactive to preventive systems approach**

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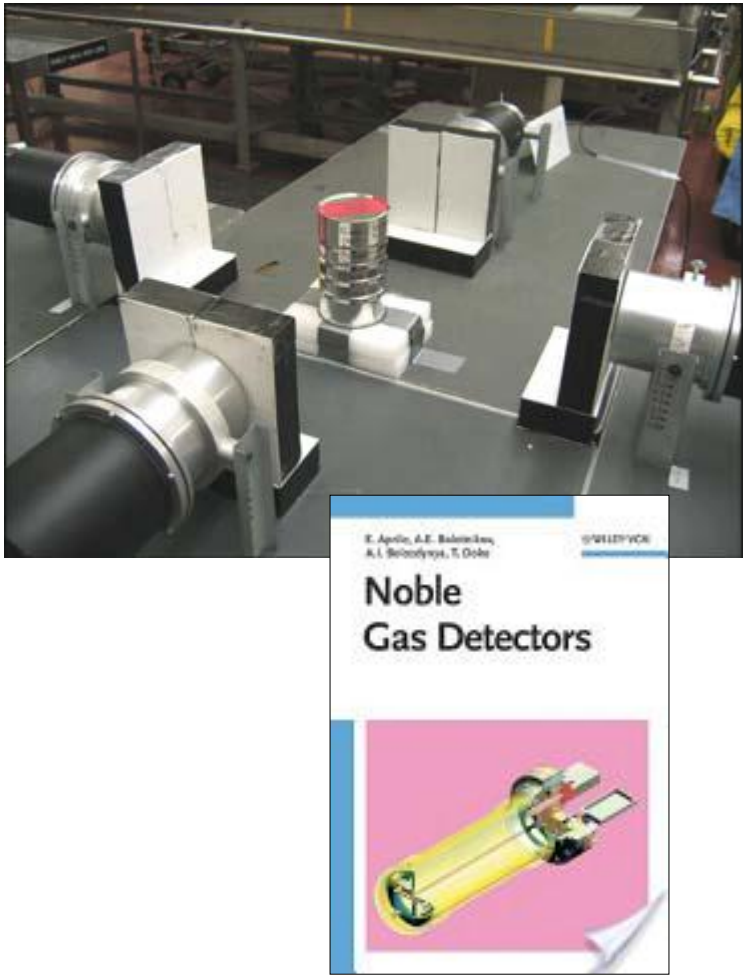
Nuclear Materials Safeguarding and Instrumentation FC-3 Focus Areas for University Proposals

- **Key university research needs for nuclear materials safeguarding and Instrumentation includes:**
  - **New "compact" innovative sensors including statistical analysis**
  - **Enable the development of advanced fuel cycle system through approaches to Proliferation Risk and Risk Reduction**



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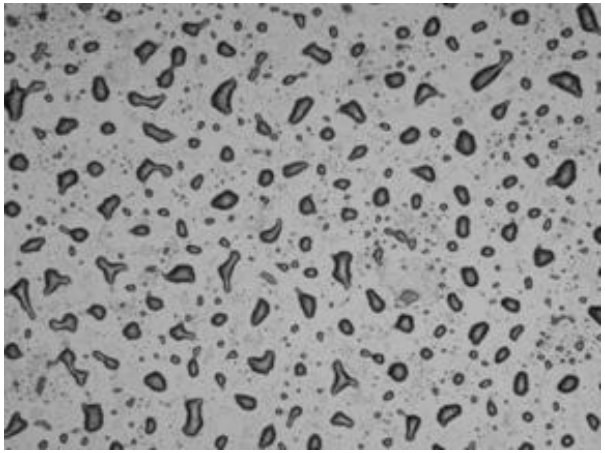
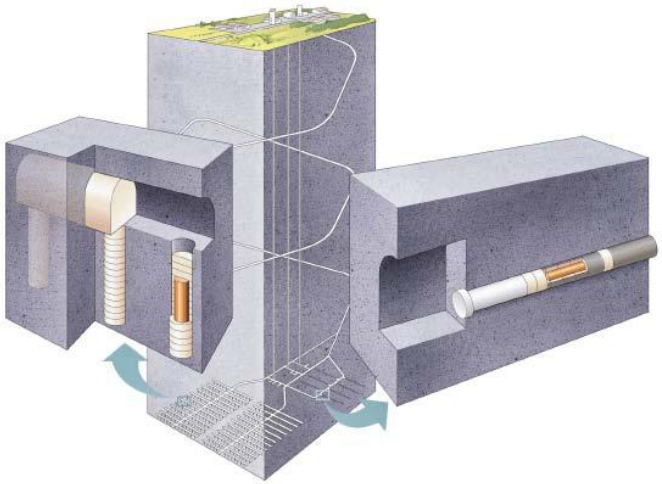
Used Fuel Disposition FC-4

- **Goals: Develop technologies for storing, transporting, and disposing of used nuclear fuel and assessing performance of waste forms in the associated storage and disposal environments**





- **Focus of the research**
  - **Transportation and storage (FC- 4.1)**
  - **Used fuel and waste form disposal options (FC- 4.2)**

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Used Fuel Storage and Transportation (FC- 4.1) Focus Areas for University Proposals

- **Key university research needs for used fuel storage and transportation includes:**
  - **Evaluating degradation and aging phenomena of fuel, cladding, containers, and storage facilities**
  - **Data to informed cask qualification and storage and transportation behavior of high burnup and advanced fuels**
  - **Superior concrete for extended storage**
  - **Materials research to facilitate transportation of used fuel**
  - **Advanced modeling approaches**
    - **Radiological consequence analysis of disruptive scenarios**
    - **Modeling data/tools relevant to disposal of UNF and HLW in variety of generic disposal concepts**
    - **Degradation of waste forms and mobilization of radionuclides, reactive transport through near field environment, and transport into and through geosphere**

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Used Fuel and Waste Form Disposal (FC- 4.2) Focus Areas for University Proposals

- **Key university research needs for used fuel and waste form disposal includes:**
  - **Quantitative chemical descriptions for UNF, glass, ceramic, and metallic waste form degradation in severe aqueous environments - validated rate laws for dissolution and release of radionuclides**
  - **Aqueous speciation and surface sorption at high temperature and high ionic strengths anticipated in near field conditions**
  - **Radiation and thermal effects in used fuel and waste forms for radionuclide transport, cracking and impacts on aqueous-accessible surface**
  - **Geochemical transport based on fundament kinetics and thermodynamics**
  - **Methods to upscale atomistic descriptions into continuum-scale models, and generate validated predictions over geologic time scales**
  - **Systematic experiments under controlled conditions targeted to model validation**

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Fuel Cycle Option Analysis FC-5

Goals:

- Develop fuel cycle option evaluation criteria and metrics
- Perform systems analysis and capture system data in a centralized database
- Perform fuel cycle option screenings to focus on technologies and systems for further development and possible demonstration
- Develop communication strategies to engage stakeholders and the public

Focus of the research:

- By 2013, complete a "system engineering" evaluation of the three fuel cycle options
  - Once through
  - Modified open
  - Full recycle
- BRC recommendations regarding comprehensive evaluation of a complete fuel cycle risk

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Fuel Cycle Options Analysis (FC-5) Focus Areas for University Proposals

- **Key university research needs for fuel cycle options analysis includes:**
  - ***Identify and develop the essential features and messages for effective communication of the fuel cycle program as related to:***
    - ***Risk inform options***
  - ***Understanding the societal and public viewpoints associated with nuclear power and advanced nuclear fuel cycles as related to:***
    - ***Respond to public needs associated with the development of nuclear fuel cycles***

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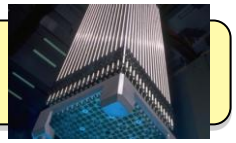
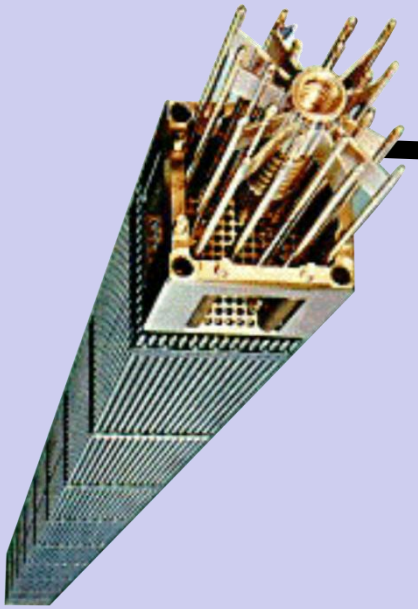
Where Do We Want to Be?

Near term – Improve management of SNF



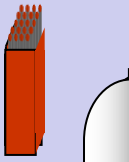
Long term – Improve resource utilization

Used Fuel

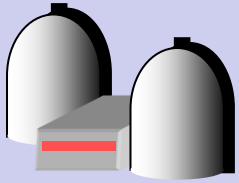


Recycle

Economically
Safely
Securely



Product
- Ease of reuse
- Retain high U/Pu ratio



Waste
- Reduce secondary streams
- Ease of Management
  - Storage
  - Transportation
  - Disposal

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Blue Ribbon Commission on America's Nuclear Future:

www.brc.gov

Nuclear Energy University Program:

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